Nuclear Gauge Safety and Operation

Construction Inspector's Training Manual

January 2006

Washington State
Department of Transportation

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Construction Office

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Part 1

Introduction

Goal

At the completion of this course you will be able to safely handle, operate and transport the Nuclear Density Gauge.

Objectives

At the completion of this course you will:

Be able to distinguish the different types of radiation emitted by the gauge and the best practice for limiting your exposure.

State and practice the philosophy of ALARA.

Be able to enter and retrieve the data required for operation of the Nuclear Density Gauge.

Know the three levels of security for transporting and storage of the Nuclear Density Gauge.

Know what to do and who to call if a Nuclear Density Gauge is damaged or stolen.

The test for determining the in-place density of materials with nuclear gauges was adopted as one of the standard methods of contract compaction testing by the Washington State Department of Transportation in June 1977. With this adoption came the task of implementing a self-contained system for the administration of all phases of nuclear testing operations by each highway region within their respective jurisdictions. To accomplish this, it has been necessary to license each region, under the laws of the state of Washington, to possess and use radioisotopes.

Possession of this license obligates the region to numerous responsibilities, among which is the requirement for training operators and other personnel associated with the nuclear gauges, in the proper handling and use of radioactive sources. Formal classroom work should be conducted as well as field training. In general, the classes cover such subjects as the fundamentals of radiation, instrumentation, health safety, radiation protection, rules and regulations, operation of the gauges, and the test methods.

WAC 246-243-230 Appendix A — Minimum subjects to be covered in training radiographers.

(1) *Fundamentals of radiation safety*

(a) Characteristics of ionizing radiation

(b) Units of radiation dose (mrem) and quantity of radioactivity (curie)

(c) Hazards of exposure to radiation

(d) Levels of radiation from sources of radiation

- (e) Methods of controlling radiation dose
  - (i) Working time
  - (ii) Working distances
  - (iii) Shielding

(2) *Radiation detection instrumentation to be used*

- (a) Use of radiation survey instruments
  - (i) Operation
  - (ii) Calibration
  - (iii) Limitations
- (b) Survey techniques
- (c) Use of personnel monitoring equipment
  - (i) Film badges
  - (ii) Pocket dosimeters
  - (iii) Thermoluminescent dosimeters
  - (iv) Alarming rate meters

(3) *Radiographic equipment to be used*

- (a) Remote handling equipment
- (b) Radiographic exposure devices and sealed sources
- (c) Storage containers

(4) *The requirements of pertinent federal and state regulations*

(5) *The licensee's written operating and emergency procedures*

(6) *Case histories of radiography accidents.*

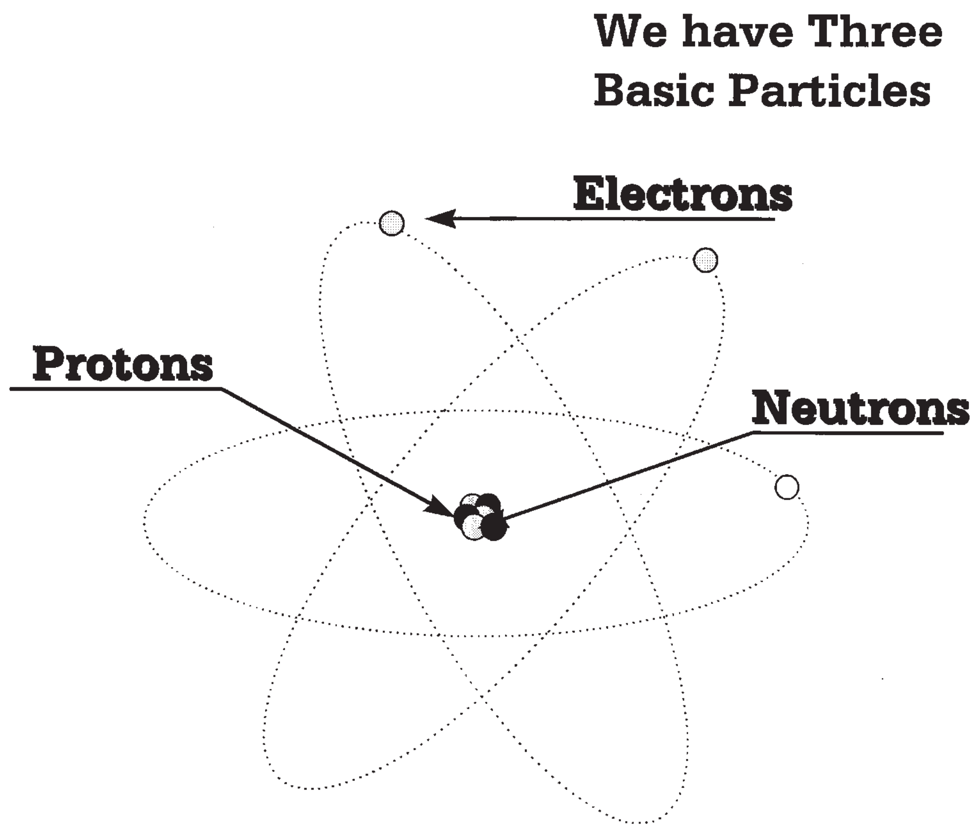
Part 2

Theory

Man has always been subjected to natural radiation. He is exposed to radiation from the sun and outer space; naturally occurring radioactive materials are present in the earth, in the structures we inhabit, and in the food and water we consume. There are radioactive gases in the air we breathe and our bodies are themselves radioactive. The levels of this natural (or “background”) radiation vary greatly from location to location.

In addition to natural radiation, man is exposed to sources of radiation that he himself created. X-rays and other kinds of radiation used for medical purposes, fall-out from nuclear explosives testing, and radioactive materials released in the course of nuclear power production are some examples. Within a decade after X-rays came into use in the late 1890s, it became apparent that this type of radiation could be either beneficial or harmful depending on its use and control, and that protection measures were necessary. In succeeding years it was realized that this also applies to some other kinds of radiation.

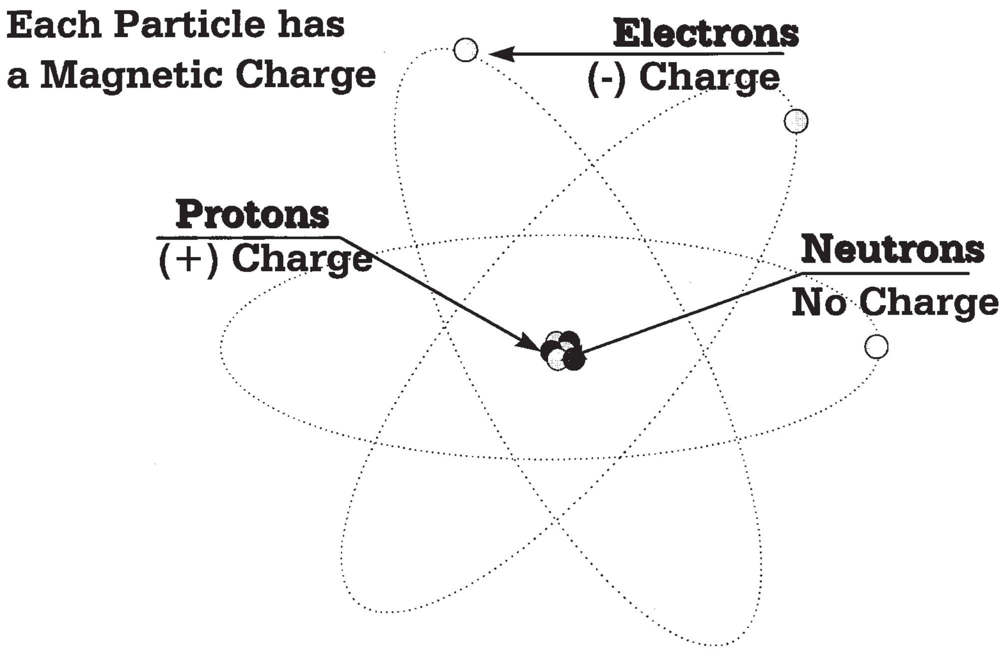
Atomic Structure



Atoms

All atoms have three basic particles — “electrons” in a cloud layer around the nucleus, “protons” and “neutrons” which make up the nucleus.

Most of the space of an atom is empty. Even solid materials consisting of billions and billions of atoms are mostly empty space.



The atom is the smallest unit into which common materials can be separated and still retain the original basic properties of the materials. Atoms consist of a nucleus and orbit electrons. The **nucleus** is a heavy central mass with a positive charge. The **electrons** are light negatively charged particles that orbit around the nucleus because of attraction by the coulomb force of the nucleus. This is similar to the action of planets around the sun.

Nucleus

The nucleus is the central mass in an atom and contains **protons** and **neutrons**. They are held together by "strong nuclear forces" that are even more complicated than the coulomb forces on electrons.

Atoms are grouped into elements according to the number of protons in the nucleus and each element has a unique number of protons.

The total number of protons and neutrons in an atom is called the **mass number** since it represents most of the atom's mass.

The number of protons (equal to the number of electrons) in an atom is called the **atomic number**.

Some examples of elements are:

Oxygen
Sodium
Carbon
Hydrogen
Iodine
Copper
Tin

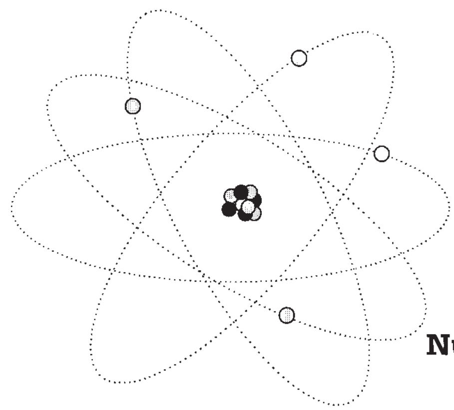
When elements are combined, they make up molecules such as:

Water

Salt

Alcohol

Beryllium = $^{9}Be_{4}$



$^{9}Be_{4}$

Number of Protons (Atomic #)

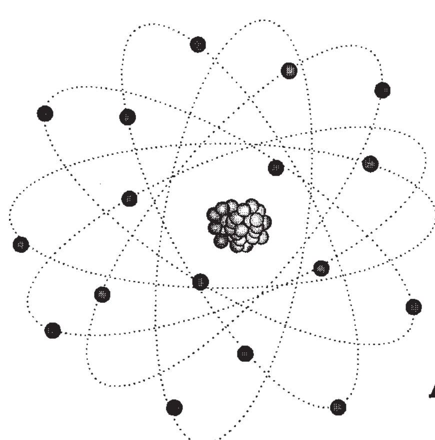
Total Number of Protons and Neutrons in Nucleus. Also called the Atomic Mass.

Beryllium is an Element used in the Troxler 3400 Series Gauges

An electrically **stable atom** is one that has the same number of **protons** in the nucleus as there are **electrons** in orbit. Atoms with a different number of electrons in orbit than protons in the nucleus are unstable and are called ions. Atoms that have a different number of neutrons than protons in the nucleus may also become unstable. Unstable atoms spontaneously release excess energy in the form of waves or particles.

Beryllium is a stable element used in our Troxler Gauges.

Unstable Atom



An <u>Unstable Atom</u> has more Neutrons than Protons in the Nucleus.

Americium = $^{241}Am_{95}$

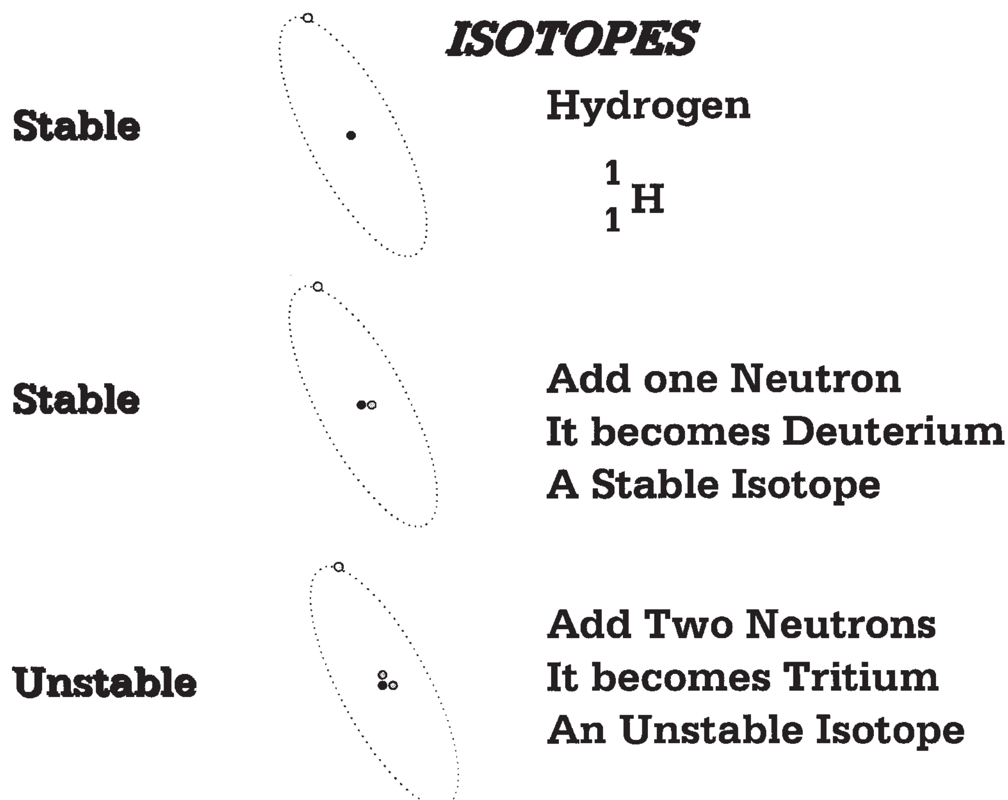
Americium is an Element used in the Troxler 3400 Series Gauges.

All atoms want to become stable. The way they become stable is to **transform** by decay or degeneration.

Americium 241 is an unstable source that is used in our Troxler Gauges.

Isotopes

Isotopes are atoms that contain a different number of neutrons in its nucleus than some other atom of the same element. Different isotopes of an element will have the same atomic number, since the number of protons remains the same, but the atomic mass will not be the same because of the different number of neutrons. Not all isotopes are unstable; the table below shows two stable and one unstable form of hydrogen.



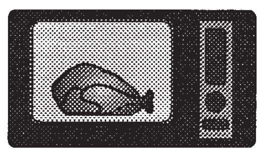
Two Types of Radiation
Non-Ionizing and Ionizing

Non-Ionizing Radiation

Non-ionizing radiation does not have enough energy to create ion pairs. Examples of radiation include visible light, radar, and radio waves.

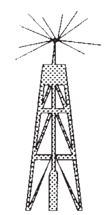
It is a common mistake to confuse microwave radiation with nuclear radiation. In sensing applications, microwave radiation is used at low levels which are completely harmless to people. It is called radiation quite simply because it radiates much like the ripples around a stone dropped in a pond. Microwave radiation is non-ionizing which means it does not.

Light



Microwave

Laser

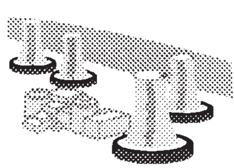


Radiowaves

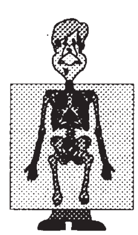
Ionizing Radiation

Although the term “radiation” is very broad and includes such things as light and radio waves, it is most often used to mean “ionizing” radiation. Radiation which has enough energy to remove electrons from the material it passes through is called ionizing radiation, which this training is about. Ionizing radiation is energy emitted from unstable atoms in the form of particles or rays, the emitted radiation transfers its energy to the material it passes through. This is true for inanimate as well as living matter, hence ionizing radiation then can represent a health hazard to man.

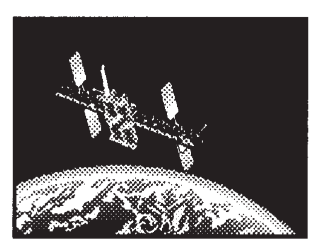
Two hydrogen atoms meet on the street. One says to the other, “I’ve lost my electron.” the other says, “Are you sure?” The first replies “Yes, I’m positive.”



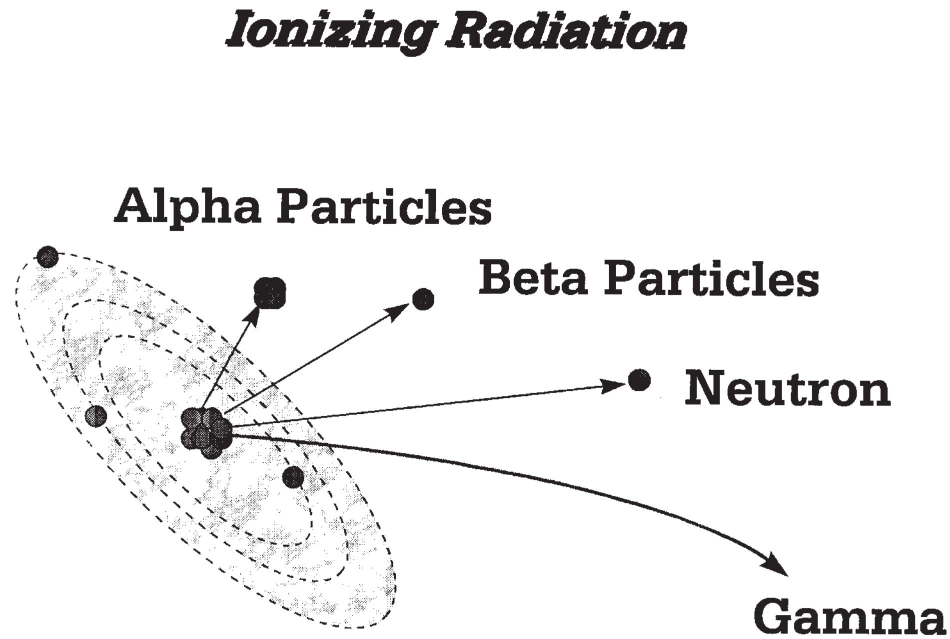
Nuclear Power



X-Rays



Cosmic



Ionizing Radiation (continued)

There are various types of ionizing radiation, each with different characteristics. The different types of particle ionizing radiation include:

Alpha

Beta

Neutron

Radiation that is emitted by waves may be either:

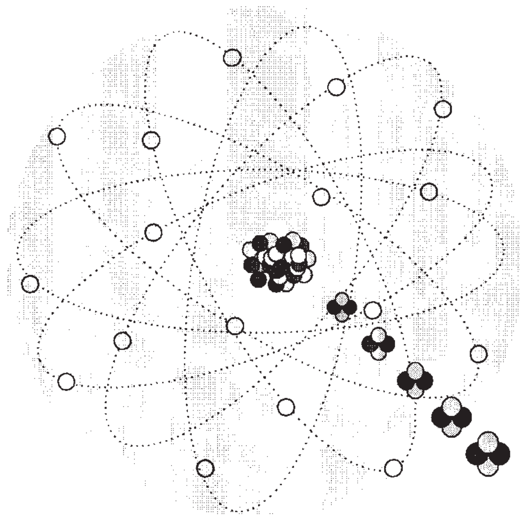
Gamma radiation, or

X-Ray

Note that the particles and Gamma radiation are emitted from the nucleus of the atom.

Natural radiation is the emitted particle (Alpha, Beta) or photon (Gamma). Induced radiation is also called neutron radiation (neutron emission) which is man-made and not normally found naturally occuring.

Alpha Emission



Alpha Particle
Symbol =

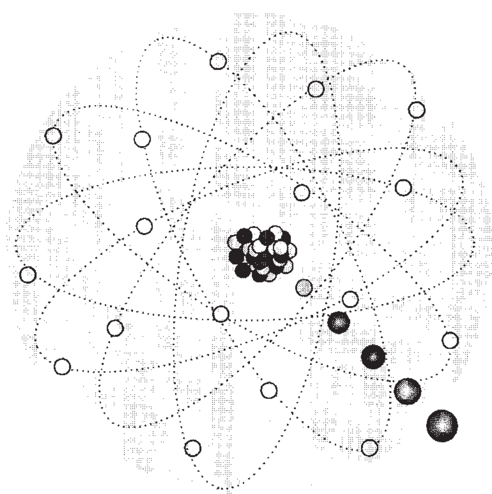
Emission:
Two Protons
and
Two Neutrons

The Alpha Particle is Emitted from...

The Nucleus.

The Alpha Particle is the heaviest particle and contains two protons and two neutrons and is emitted from the nucleus of the atom. The Alpha Particle will not penetrate the outer layer of the skin.

Beta Emission



Beta Particles are lighter than Alpha Particles.

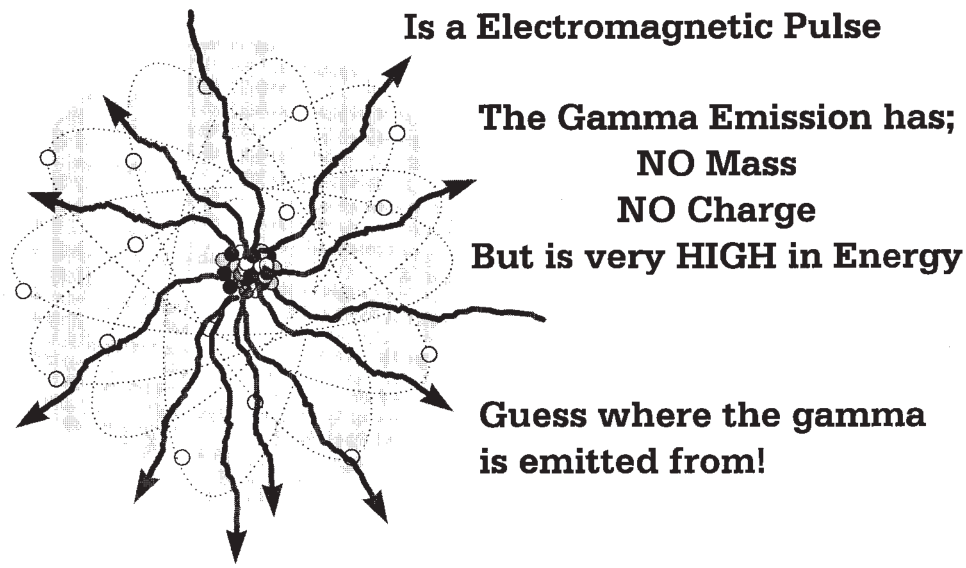
The Neutron decays into a Proton and an Electron is ejected.

Beta's are emitted from the ...... Nucleus.

The Beta Particle is lighter than the Alpha Particle, and it too is emitted from the nucleus of the atom. A Beta Particle acts like an Electron and when a Beta Particle is released, a neutron within the nucleus changes to a Proton.

A Beta Particle can be stopped by thin layers of metal or plastic.

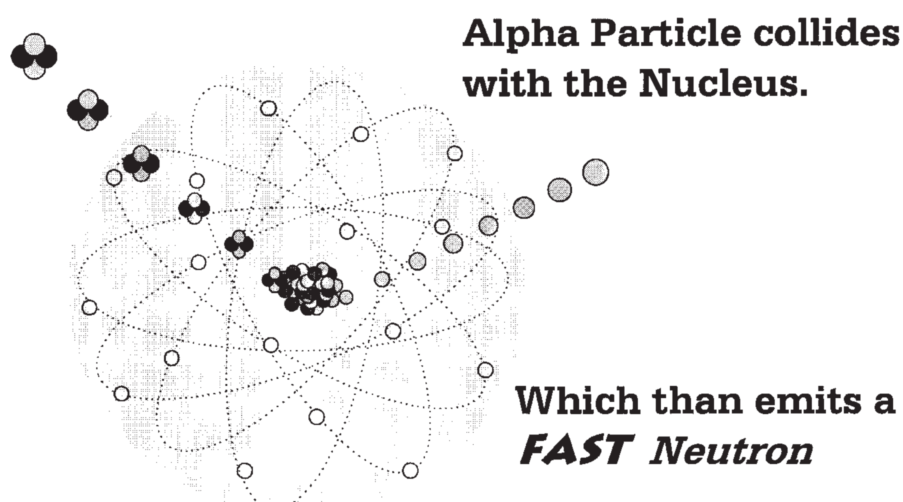
Gamma Emission



After the atom has had a decay reaction, the nucleus is in an excited state. This means that the decay has produced a nucleus with excess energy. This energy is lost by emitting gamma radiation in the form of a photon. A gamma emission has no mass and no charge.

The Troxler Gauge uses the element Cesium-137 to produce gamma photons.

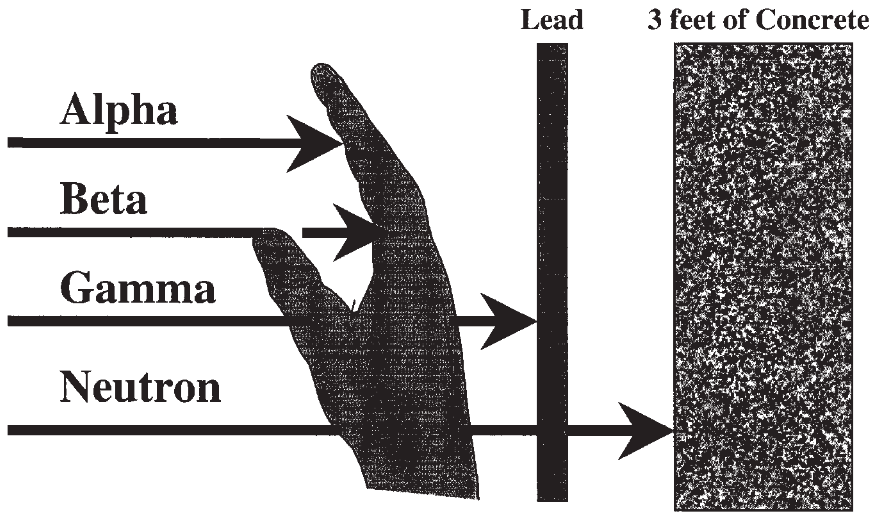
Neutron Production



Neutron radiation is man-made and not normally found naturally occurring and is used in the generation of nuclear power. Since Neutrons have no electrical chage and are high in kinetic energy, the only thing that slows them down are collisions with hydrogen atoms.

To create Neutron radiation, you take a stable element like Beryllium and introduce an unstable element (Troxler uses Americium) to remove Neutrons from the Beryllium's nucleus.

The Penetrating Power Of Radiation



Remember RADIATION Travels in all Directions

Alpha Particles

These particles have a positive electrical charge. Because of the relatively large size of these particles, they collide readily with matter and lose their energy quickly. Therefore, they have little penetrating power and can be stopped by the first layer of skin or a sheet of paper.

Beta Particles

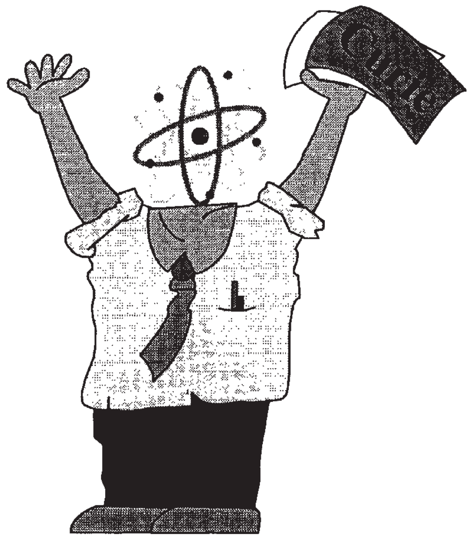
These particles have a single negative charge and only weigh a small fraction of a neutron or proton. Since Beta Particles are smaller than an Alpha Particle, they interact less readily with matter. Depending on the energy of the Beta Particle, they can travel up to several meters in the air and are stopped by thin layers of metal (such as aluminum) or plastic.

Gamma

Since gamma rays have no mass or charge, they interact with material by colliding with the electrons in the shells of atoms. Gamma rays lose their energy slowly in material and are able to travel large distances before stopping. Depending on the initial energy of the gamma ray, they can travel from one to hundreds of meters in the air and can easily go through the human body. Dense material such as lead and tungsten are used for shielding.

Neutrons

Neutrons have no electric charge, are high in kinetic energy, and very penetrating. Neutrons are slowed down by collisions with hydrogen atoms. For shielding, materials high in hydrogen such as polyethylene are used. Keep the gauge in the yellow transport box when not in use to shield neutron radiation.



Measurement of "Transformations per Second"
1 Curie (Ci) = 37 billion transformation / second

The unit of radioactivity is the Curie, which is the number of transformations/unit of time.

1 Curie = 37 billion transformations per second

1 Becquerel = 1 transformation per second

R adiation

A bsorbed

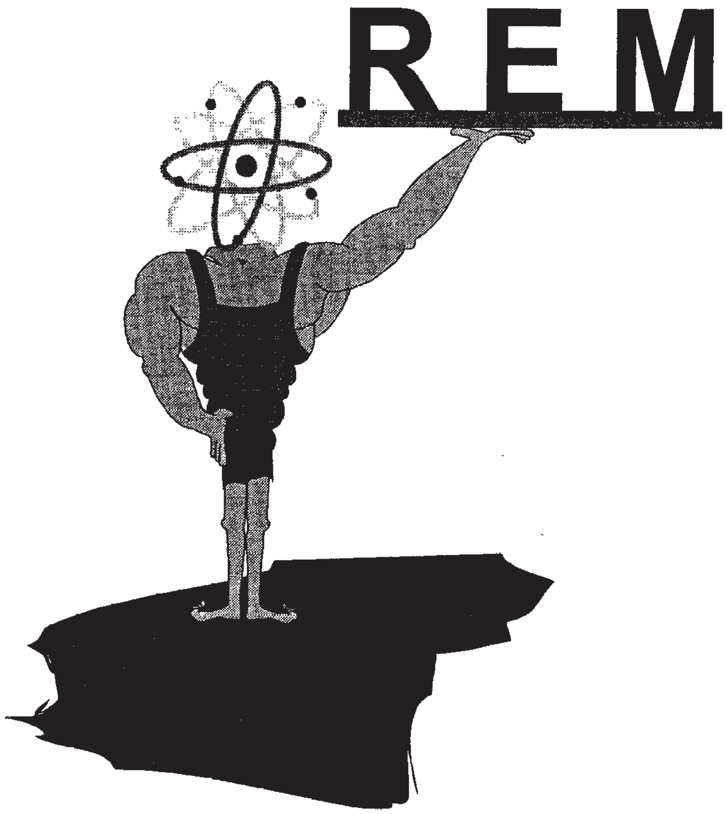
D ose

This is used to measure the amount of radiation absorbed in any medium ...

RAD — This unit is the amount of energy radiation absorbed in any medium, such as air, living tissue, or soil. The **RAD** is not a good indicator of the biological effect or the efficiency of a certain type of radiation to effect living tissue. So. . .

The Quality Factor (QF) was developed. The QF, an assigned value based upon a type of radiation's ability to affect change, was derived. The QF for:

Alpha	20
Beta	1
Gamma	1
Fast Neutrons	10
Slow Neutrons	5



REM

Knowing the measured unit, the rad and the type of radiation, and therefore, the Quality Factor, the REM (Roentgen Equivalent Man) can be calculated.

Examples of REM dosage is:

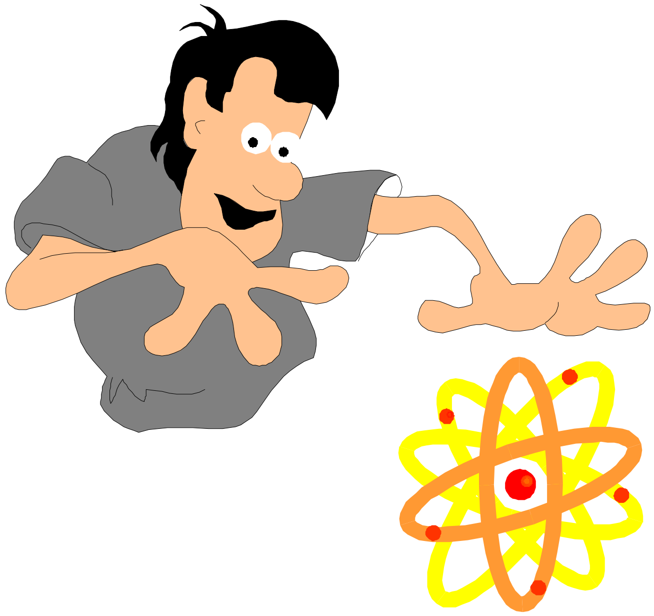
Radiation Type	Dose Rad	QF =	Dose in REM
Gamma	0.25	1	0.25
Slow Neutron	0.15	5	0.75
Fast Neutron	0.05	10	0.50
Total Dose			1.50

Example Problem	Radiation Type	Dose in Rad	QF`	Dose in REM
	Gamma	0.080	1	
	Fast Neutron	0.010	10	
	Slow Neutron	0.005	5	
	Total Dose			

The REM is the measurement of radiation received that takes into account the biological effectiveness.

Millirem — One one-thousandth of a REM (.001 REM).

HALF- LIFE?



Half Life

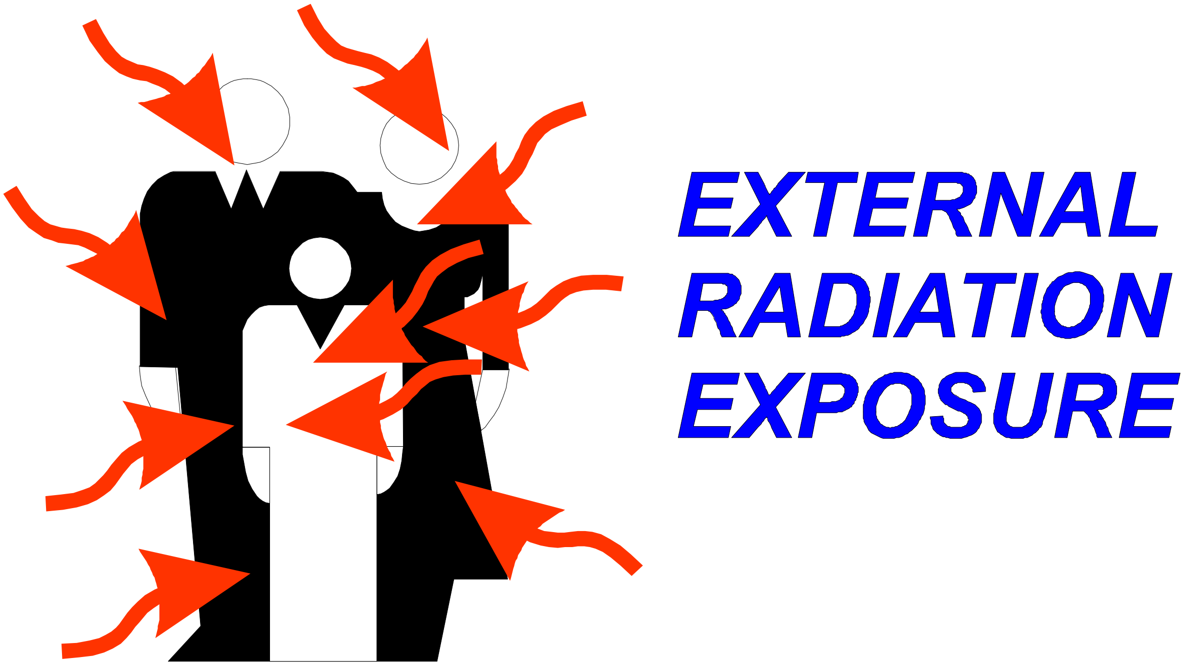
Half life is the time it takes for 50 percent of a radioactive isotope to decay or transform to another isotope or element.

The rate of decay of a radioactive isotope is measured by half life. The half life of a radioactive isotope varies for different elements, but is constant for each isotope.

To Illustrate — The Troxler 3400 series is loaded with 8 m Ci of Cs-137. Half life for Cs-137 is 30 years; therefore, at

0 years	there is	8 m Ci.
30 years		4 m Ci.
60 years		2 m Ci.
90 years		1 m Ci.

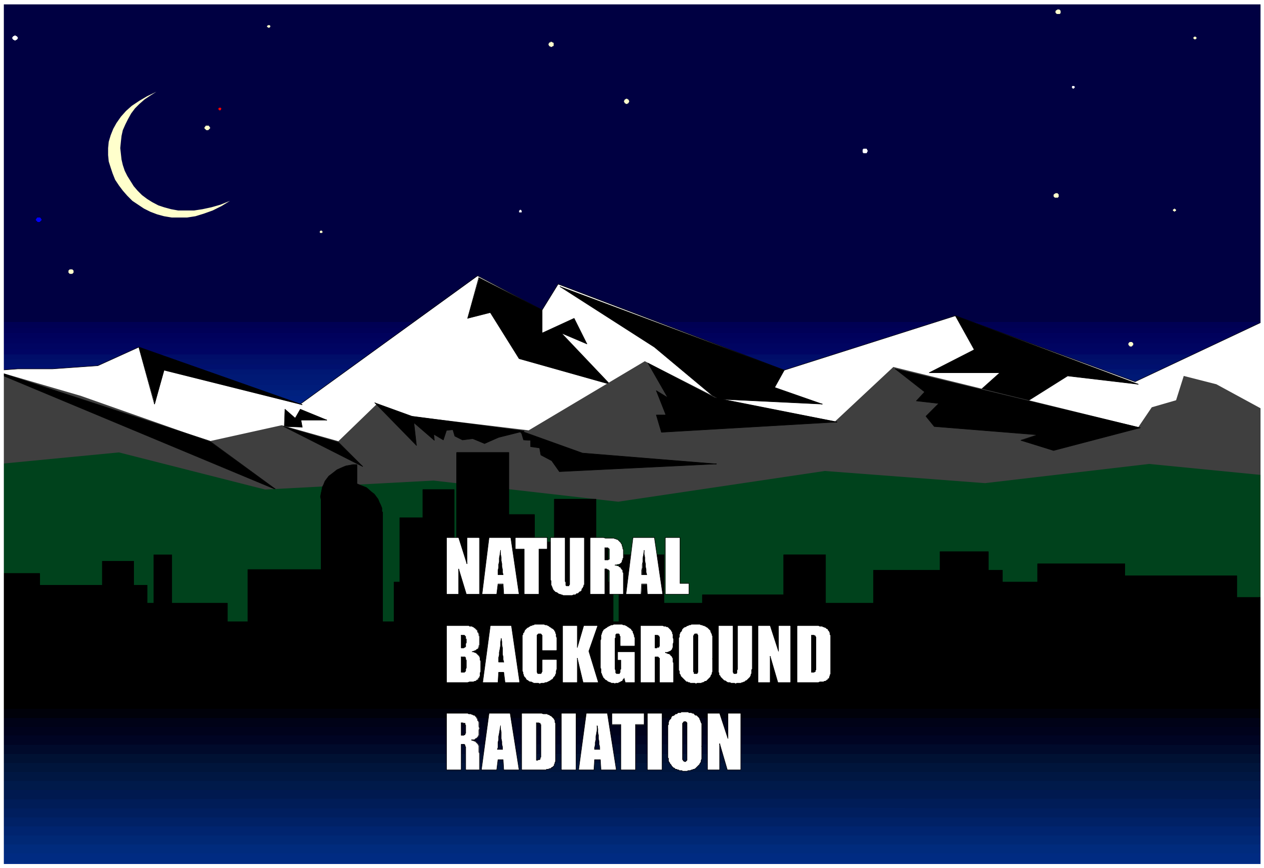
Question — If a medical patient is injected with 100 m Ci of Technetium-99, which has a half life of six hours, at noon on Saturday, what is the remaining radiation level at noon on Sunday?



External Radiation Exposure

From a safety standpoint, our main concern is exposure to external radiation. We are exposed to radiation in many ways. Some common forms are:

- Airborne activity
- Global fallout
- Nuclear power plants
- Medical X-rays

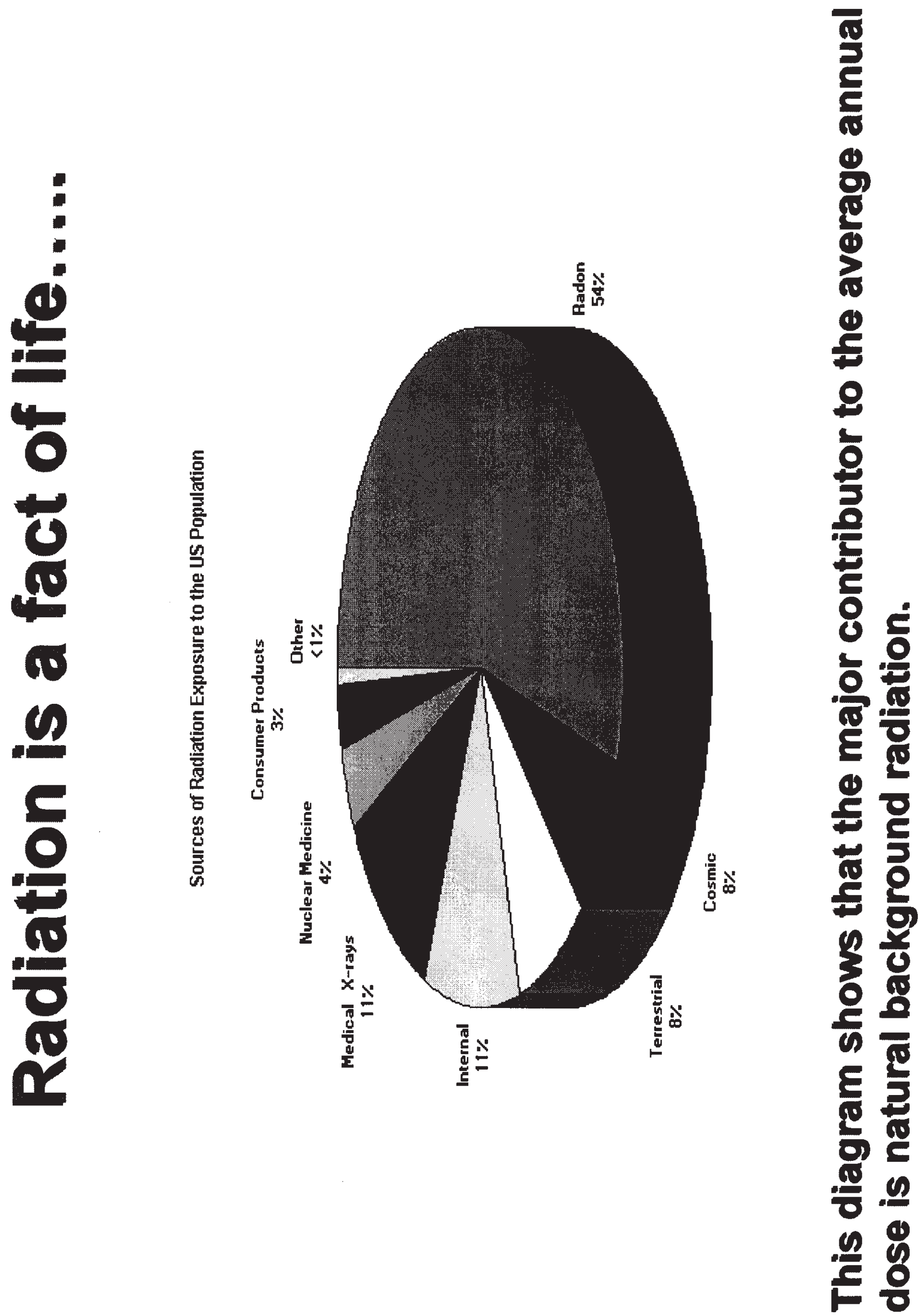


Natural Background

Natural background radiation, another source of external radiation exposure, exists everywhere. Natural background radiation varies in intensity based on exposure to the sun, altitude, or where you live in relation to the equator.

- Flying
- Altitude
- Large stone buildings
- Rock quarries
- Waste

The average annual dose of radiation to every man, woman, and child is about 360 millirems.



This diagram shows that:

- The major contribution to the average dose is from natural background radiation.
- The largest man-made contribution is from the medical uses of radiation.
- The nuclear power industry is a small contributor to the average radiation dose.

4:P65:DP/NGOQC

Summary

- Radiation has always been a part of the natural environment and a large part of the radiation dose we receive naturally is unavoidable.
- The effects of radiation on human health are not unique; many natural and man-made materials can produce similar effects.
- The effects of radiation are better known than those of practically all other harmful agents and the regulations and monitoring measures to protect us against these effects are more complete and more advanced.
- The benefits of radiation and radioactive materials, in their various uses, greatly outweigh the risks.
- The nuclear power industry is a very minor contributor to our total radiation dose.

Part 3

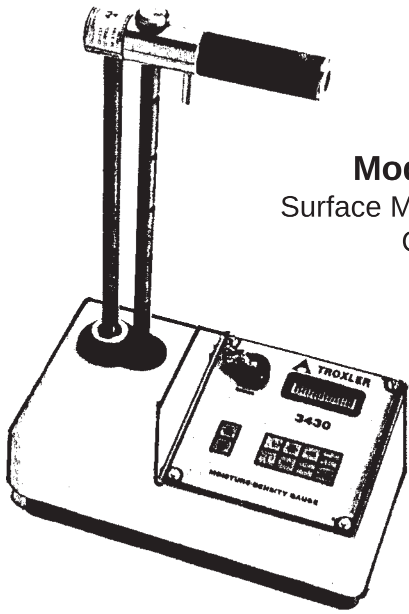
Gauge Operations

Washington State Department of Transportation Nuclear Moisture/ Density Gauge

Operations

Models

Troxler 3430	Density Gauge
Troxler 3450	Density Gauge



Model 3430
Surface Moisture-Density
Gauge

ON / YES	
OFF / NO	

↑	MA / PR	STD	SPECIAL
↓	TIME	DEPTH	START / ENTER

The 3430 keypad consists of 10 keys: the 8-function keypad and the **ON** and **OFF** keys. The gauge is equipped with a “beeper” to verify that keypresses were received by the gauge. If a “beep” is not heard, the keypress did not “take” and should be repeated. The **YES** and **NO** keys are used for responses to specific questions displayed on the screen. The “up” and “down” arrow keys allow scrolling through the various function lists displayed by the gauge.

KEYS	DESCRIPTION	PAGE
ON/YES	Turns gauge ON or answers Yes	
OFF/NO	Turns gauge OFF or answers No	
↑	Scrolls display up	
↓	Scrolls display down	
MA/PR	Select MARSHALL/PROCTOR	
TIME	Selects COUNT TIME intervals	
STD	Enter STANDARD COUNT mode	
DEPTH	Enter DEPTH of source rod	
SPECIAL	Selects the SPECIAL FUNCTIONS	
START/ENTER	Start a measurement/ENTER answer	

Handling Procedures

While exposure dose levels are well within limits for radiation workers, never expose yourself to the bare source without sufficient reason to justify the additional dosage.

DO NOT leave the gauge unattended. This is a requirement of our license with the Department of Health – Radiation Division. Maintain security of the instrument at all times. The gauge should be returned to the carrying case when not in use with the source rod in the shielded position.

Transporting

1. Do not operate or attempt to operate the instrument unless you have been authorized to do so.
2. Keep the source in the safe position or stored position (source rod completely retracted) when not in use. The polyethylene case is an effective barrier from neutron radiation, so when not in use keep the gauge inside the case.
3. Wear a TLD badge when using or transporting the instrument (see “Part 4 Safety”).
4. Prior to removing the instrument from gauge storage location log out gauge in log book. The following information is required in log book;
    a. Date
    b. Location or contract number where the gauge to be used
    c. Identifying number (serial number) of the gauge
    d. Full legible signature of the person checking out gauge
5. Turn on instrument. A minimum warm up time of 10 minutes is required.
6. Make sure you have keys to all locks that accompany the gauge.
7. Block and lock instrument carrying case in the vehicle with gauge stored and locked within the carrying case.
    a. WSDOT requires 3 levels of security.
        i. Gauge handle and case locked
        ii. Gauge case chained and locked
        iii. Exterior surrounding gauge case locked
8. Gauge and case not visible when gauge not in use.
9. Before leaving make sure “Transportation Information” Sheet is visible within the vehicle before transporting (see “Part 4 Safety”).
10. You are now ready to transport the nuclear gauge.

Job-site Arrival (WSDOT FOP for AASHTOT 310)

Standard Counts

Prior to any density-moisture testing using the nuclear gauge a standard count must be completed with the moisture and density standards within the required ranges. A standard count is done at the job-site to check for source decay, gauge stability and to adjust for background radiation.

1. Verify the gauge has had the required warm up time.
2. Remove the gauge and standard block from carrying case and remove lock from gauge handle.
3. Verify that standard block has the same serial numbers as the nuclear gauge.
4. Place the standard block on a high dense flat surface such as;
    a. Concrete
    b. Compacted asphalt pavement
    c. Compacted subgrade or surfacing material.
5. Place the gauge on the standard block per the manufacturer's requirements (see next page).
6. Make sure the gauge handle is all of the way up with the source rod fully retracted into the gauge.
7. Make sure that the gauge fits evenly on the block.
8. No other radioactive source, large body of water or large vertical surfaces within the manufactures recommendations during the standard count.
9. Follow manufactures instructions for starting standard count.
10. The gauge will count for 4 minutes.
11. At the end of 4 minutes note the;
    a. Moisture Standard (MS)
    b. Density Standard (DS)
12. The gauge stability has to be within,
    a. 2 percent of the average of the previous 4 counts for MS
    b. 1 percent of the average of the previous 4 counts for DS
13. If the days standard count falls within the tolerance bands record today's readings.
14. You are now ready to perform record density testing.
15. If the readings do not fall within the tolerance bands, reposition the gauge and try again.

	Date	*MS*	*DS*	*Initials*
	7-09-01	656	2591	TM
	7-10-01	648	2571	TM
	7-11-01	661	2582	BD
	7-12-01	663	2569	MD
	7-16-01	651	2590	MD
	7-18-01	657	2584	BD
	7-19-01	647	2592	TM
Today's Reading	**7-22-**01	**645**	**2566**	**MD**

MS	DS
663	2569
651	2590
657	2584
647	2592
2618	10335

Last four readings average. . . 2618 / 4 = **655** 10335 / 4 = **2584**

Moisture Standard (MS) must be within +/- 2% (0.02)
Density Standard (DS) must be within +/- 1% (0.01)

Determine Tolerance: **MS**: 655 x 0.02 = **13** **DS**: 2584 x 0.01 = **26**

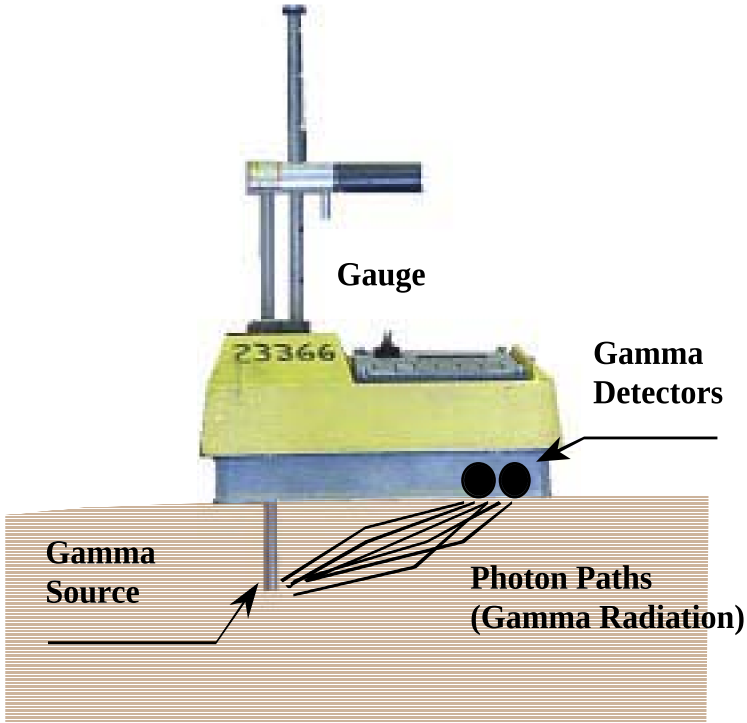
Tolerance Band for MS:
655 - 13 = **642** 655 + 13 = **668** Today's MS must be within. . . . **642** to **668**

Tolerance Band for DS:
2584 - 26 = **2558** 2584 + 26 = **2610** Today's DS must be within. . . . **2558** to **2610**

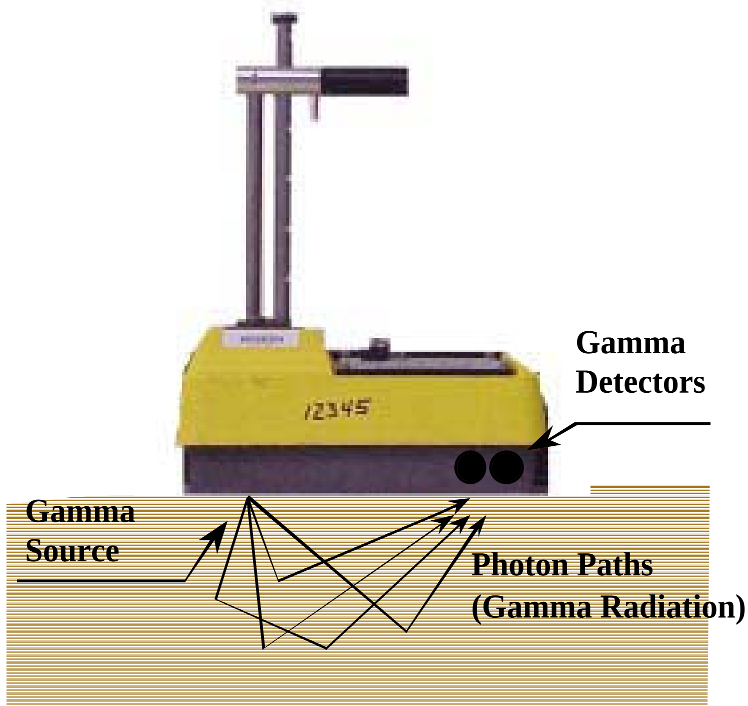
Exercise

	Date	*MS*	*DS*	*Initials*
	7-05-01	677	2830	MD
	7-06-01	674	2825	BD
	7-07-01	672	2827	MS
	7-08-01	654	2801	DE
	7-12-01	666	2834	JT
	7-14-01	661	2819	VF
Today's Reading	**7-18-**01	**675**	**2798**	**BB**

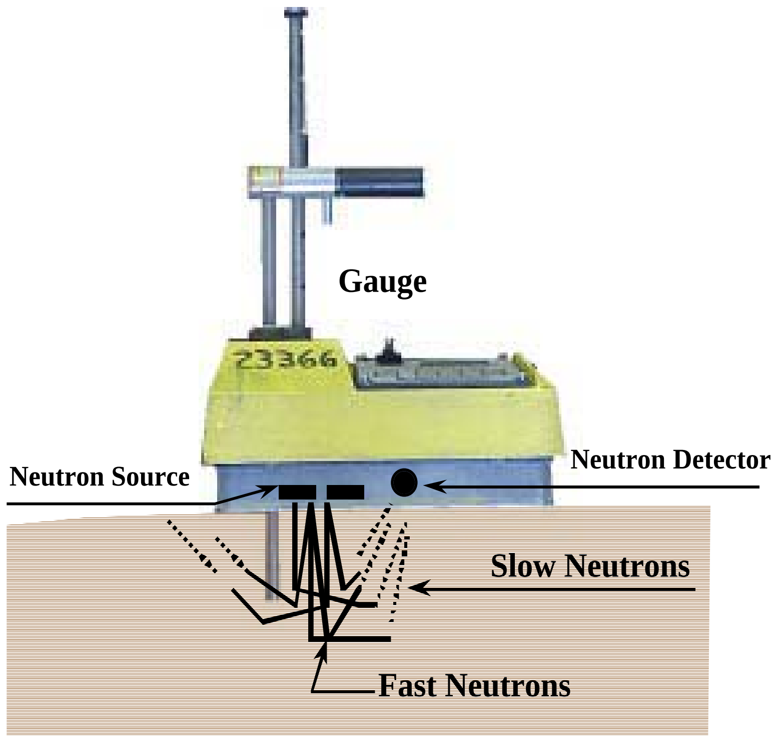
What are the acceptable ranges for moisture and density standards and do today's readings fall within the acceptable ranges?



Direct Transmission Density Geometry



Backscatter Density Geometry



Backscatter Used for Moisture Determination

The gauge's depth of measurement for moisture is a function of the moisture content. the higher the moisture content in the material being measured the smaller the depth of measurement.

The typical moisture content of the materials we test range from 5% to 17%, therefore the effective depth of measurement would range in a corresponding depth of 10 inches to 8 inches.

Procedure for Taking a Test Count in Direct Transmission Mode (3430)

Earthwork and Surfacing

1. Make sure a standard count has been taken before doing a test count. Standard count should be done at the job site.
2. Locate and prepare test site as follows:
   a. Using the scraper plate supplied with the instrument, carefully scrape the surface to smooth condition, removing all dried and loose material. If the scraping action dislodges surface stones, remove them, fill the voids with fine native material screened through the #4 sieve, and lightly tamp the surface.

   b. Place the scraper plate in the middle of the site and drive the drill rod into the soil using a hammer. Placing one foot on the plate will prevent it from slipping or otherwise damaging the site by allowing the drill rod to move from side to side. Safety glasses should be worn to protect the operator's eyes in the event a breakage occurs either on the hammer face or the drill rod. The rod should be driven into the soil at least 2 inches further than the depth of the measurement.

      The instrument is capable of taking measurements to a maximum depth of 8 inches in 2 inch increments.

   c. In most cases, the rod can be withdrawn simply by pulling upward on the rod cap. If required, the scraper plate can be lifted up and used to lightly tap and pull the rod from the soil. Care should be used to prevent damage to the hole.

   d. If a light mark is scribed around the scraper plate, it will be easier to position the gauge over the hole. The size of the plate and guide location matches the base of the gauge.
3. Set up gauge on test site as follows:
   a. Whether you are recording a wet density or a dry density, when performing an acceptance test it is always done in direct transmission mode. Backscatter is only used to provide informational readings or when instructed too by the contract special provisions. Place the instrument over the site so that the source rod lines up with the hole. Depress the trigger and push the handle down to the properly indexed position at the desired depth. Be certain that the trigger is indexed into the slot in the index rod and not pushed below the slot. This is easily determined by pulling up and down on the handle without depressing the trigger. Pull the gauge towards the keypad to seat the source rod against the side of the hole.

   b. Press TIME, set gauge to one minute.

   c. Press DEPTH, set gauge to desired test depth.

   d. Press START/ENTER, gauge will now go through a one-minute count.

e. Rotate the gauge at least 90 degrees and press START/ENTER, and go through another one-minute count. Check the validity of the two readings, ±3 PCF for embankments and Hot Mix Asphalt pavements.

f. Retract the source rod and remove the instrument from the test site.

Note: The remainder of the test method is covered in the nuclear gauge application course, course code ANQ.

Hot-Mix Asphalt (WSDOT FOP for WAQTC TM-8)

1. Preparation of the test site is the same as for earthwork except:
   a. Surface is not scraped
   b. Drill rod is driven $^{1}/_{4}$ inch past requied test depth.

Nuclear Gauge Maintenance

1. **DO NOT** apply grease to nuclear gauge source rod. If source rod becomes hard to extend or retract, contact your Regional Radiation Safety Officer. Applying grease to source rod will increase the chance of getting small particles into the trigger mechanism.
2. Do not leave nuclear gauge carrying case open to the elements. Moisture can condense inside the nuclear gauge causing damage to the electronics.
3. Keep the nuclear gauge carrying case clean. Just like moisture, small particles of dust can get into the nuclear gauge, which could result in problems with the trigger mechanism and electronics.
4. **DO NOT** open any part of the nuclear gauge without the permission of your Regional Radiation Safety Officer.
5. Charge the batteries only when necessary. The Troxler gauges use NiCad batteries that will develop a short battery life if the gauge gets recharged too often, and without being fully discharged. It would also be a good habit to write in the log book ever time batteries get recharged. If you observe a gauge requiring frequent recharging, contact your RSO to get fresh batteries installed.

Part 4

Safety

Describe WAC 246-220, WAC 246-221 and WAC 246-222

Washington State agreements states, all laws follow National Regulatory Commission (NRC), administered by the Washington State Department of Health Radiation Division.

You are instructed to read the above WAC's.

All Regions Licensed

In the regions, all standby areas are licensed. Operators are authorized users from the Department of Transportation. Licenses for the gauges are issued through the Department of Health.

Standards

Unrestricted Area: Is any area where the external dose will not exceed 2 mrem in any one hour. When the source rod is in the safe position, fully retracted into the gauge housing, the area is considered unrestricted.

The handle will be in the fully retracted position for:

- Storage
- Transporting
- Standard Count

Restricted Area: Is an area where the external dose exceeds 2 mrem in any one hour. When the source rod is exposed the area around the nuclear gauge is now considered a restricted area.

When the source rod is exposed:

- All non-monitored persons kept away a minimum of 15 feet.
    - This includes contractor personnel, fellow workers, supervisors anyone without a dosimeter.

Permissible Levels of Radiation (Restricted Areas)

Acceptable levels or Occupational dose (on the job radiation minus background radiaton):

- Whole body – is 5 REM or 5000 milliRem

Radiation received depends on:

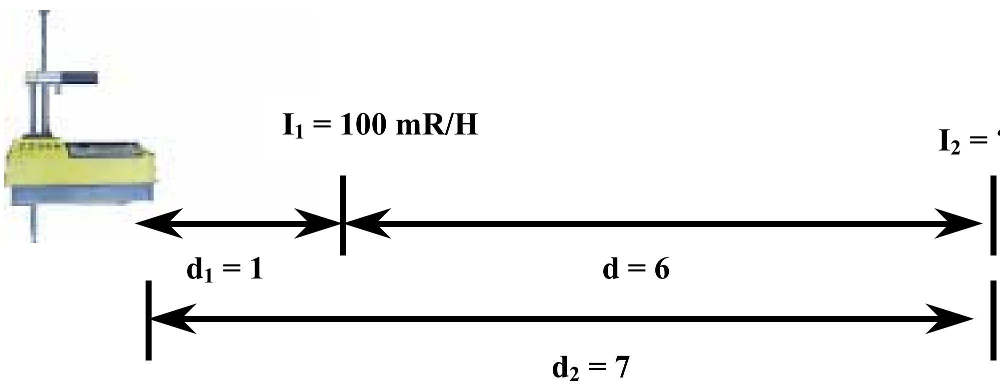
- Intensity of the source
- Distance from the source
- Length of exposure time

We cannot control the intensity of the source but we can control our time and distance. Distance is not only very effective, but also in many instances the most easily applied principle of radiation protection. Alpha and beta particles from a single energy source have a finite range in the air. So maintaining distance from the source limits the amount of alpha and beta particles received.

The inverse square law for reduction of radiation intensity applies for point sources of X-ray, gamma and neutron radiation. X-ray tubes act sufficiently like point sources so that reduction calculations by this law are valid. Gamma ray sources whose dimensions are small in comparison to the distances involved may also be considered point sources. The inverse square law states that radiation intensity from a point source varies inversely as the square of the distance from the source. Expressed mathematically;

$$I_2 = I_1 \left[\frac{d_1}{d_2}\right]^2$$

Where I_1 is the radiation intensity at distance d_1 from the source and I_2 is the radiation intensity at distance d_2 from the source. Inspection of this formula will show that doubling the distance from the source decreases intensity by a factor of



$$I_2 = I_1 \times \left[\frac{d_1}{d_2}\right]^2$$

$$I_2 = 100 \times \left[\frac{1}{7}\right]^2$$

$$I_2 = 100 \times \frac{1}{49}$$

I_2 = **2 milliRem per hour**

four; increasing the distance by a factor of three reduces the radiation intensity to one-ninth of its value, ect. The inverse square law does not apply to extended sources, radiation fields due to multiple sources, or to beams of radiation.

Example

WSDOT practices what is called ALARA. ALARA is an acronym used by the radiation industry to emphasize their dedication to safety. ALARA stands for:

As
Low
As
Reasonably
Achievable

Leak Test

Performed every six months by Radiation Safety Officer (RSO). The Leak Test is done to look for removable contamination from the source rod.

Back Strain

The nuclear gauge alone weighs approximately 30 pounds with the outer case and other required equipment the total weigh is approximately 80 pounds. Caution must be used whenever lifting of the gauge is required. Remember, use proper lifting techniques!

It is suggested when transferring the gauge from the storage unit to the vehicle and back to the storage unit that you seek assistance or use a handtruck to carry the case with the gauge. If assistance is not available consider transferring the gauge and case as two separate units to help reduce the total weight that is required to be lifted.

If it is anticipated that you will have to carry the gauge a long distance you should consider getting a hand truck or wagon to carry the gauge between test locations.

Personnel Monitoring Equipment

TLD Badges

This device stores the excitation energy in a trap. When these materials are heated, the trapped energy is released and emitted as light. The released light is proportional to the initial dose. These materials are called thermal luminescent dosimeters, TLD. They are used at WSDOT by all operators and monitored quarterly.

This complete unit to be worn on outside of clothing on trunk of body.

This side must face away from body.

Complete TLD Badge

This portion of the badge to be returned to Radiation Safety Officer (RSO) quarterly

Care of TLD

- Use only your own badge. Exchanging of badges is not allowed.
- Use only when operating and/or transporting the gauges
- Store away from radiation sources. Do NOT stored with gauge.
- Wear with the your name side facing away from body.
- Exchange quarterly when requested by Radiation Safety Officer (RSO).

Transportation Information

A copy of your regional transportation information card must be visible in the driver's compartment of all vehicles carrying a nuclear gauge. Each model gauge has its own regional transportation information card. Be sure to remove it when not carrying a gauge.

When gauges are being transported to and from their storage area, they will be blocked and locked down securely in the bed of a pickup or in the back of a van. A cable or chain, along with a good lock, should be used. This will prevent them from bouncing around, and in the case of an accident, they will be secure. During transport or when gauge is not in use, the gauge shall not be visible from outside the transport vehicle. The *Construction Manual*, Chapter 9-6.1 goes into more detail.

Paper Work

Documents that should be in the transport box:

- Bill of Lading/Transport Information Sheet
- Radiation Emergency Handbook
- Operator's Manual
- Attachment "B" of Radioactive Materials License
- STD Count Log Book

TRANSPORTATION INFORMATION

OWNER OF DEVICE:	WASHINGTON STATE DEPT OF TRANSPORTATION	
ADDRESS:	XXXXXXXXXXXXXXX MS-XX XXXXXXXXXX, WA 98XXX	
PHONE NO:	(XXX) XXX-XXXX	(XXX) XXX-XXXX
DEVICE:	TROXLER NUCLEAR DENSITY GAUGE	
MODEL:	3400 SERIES	
ISOTOPE:	CESIUM 137	AMERICIUM 241 :BERYLLIUM
ACTIVITY:	NOT TO EXCEED 10 mCi (0.37 GBq) PER SOURCE	NOT TO EXCEED 50 mCi (1.85 GBq) PER SOURCE

LABELING:

PROPER SHIPPING NAME:	RQ, RADIOACTIVE MATERIAL, SPECIAL FORM, N.O.S.
HAZARD CLASSIFICATION:	CLASS 7
IDENTIFICATION NUMBER:	UN2974
PACKAGE:	TYPE "A"
RADIOACTIVE LABEL	YELLOW II
TRANSPORT INDEX:	0.3

This is to certify that the above-named materials are properly classified, described, packaged, and marked, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

SIGNED: ______________________________

TITLE: WSDOT XX REGION RADIATION SAFETY OFFICER

DATE: ______________________

THIS PAGE SHOULD BE VISIBLE IN THE CAB OF ANY VEHICLE TRANSPORTING A

NUCLEAR DENSITY GAUGE

EMERGENCY PROCEDURES IN CASE OF AN ACCIDENT

GENERAL: The operator must protect human life first, then property, from damage due to a radiation incident. We must prevent the raw radioactive material from escaping to the atmosphere or environment.

The source material is encapsulated in two stainless steel, welded containers which are further mounted into the gauge enclosure. It is highly unlikely that the material could escape in the event of a severe accident or fire; however, our protective program must insure that we plan for this eventuality.

The first action to be taken in the event of an accident with the nuclear moisture/density gauge is to keep other people away from the site.

THEN TAKE THE FOLLOWING ACTIONS according to the extent of the accident as described in condition A or B:

A. The gauge is superficially damaged, dented, flooded, or otherwise injured from a drop, minor run over, etc. The enclosure is in one piece with a minor break or two in the sheet metal or casting and the source is obviously in place -- at **least the source location is not torn apart.**

1. **Turn the gauge over to view the source area, if necessary. Do not walk through the site material where the gauge was pushed or pulled. Inspect the source area visibly to insure no damage to shutter or source mounting.**
2. **If source area is intact, pick up gauge, place in storage container, and return to permanent storage area.**
3. **Call the Radiation Safety Officer, Project Engineer, and Headquarters Materials Lab for assistance in shipping the gauge back to the Headquarters Materials Lab for repair or disposal.**

DO NOT SHIP THE GAUGE WITHOUT THE HQ LAB'S APPROVAL OR KNOWLEDGE.

B. The gauge is broken apart, severely burned, severely crushed with parts strewn around, or the source area is visually damaged.

1. **Freeze the site. (Contain the damage site for 15 feet in any direction.) Do not walk through the damage site. If radioactive material is loose, it can be picked up and tracked elsewhere.**
2. **Call the District Radiation Safety Officer, the Project Engineer and/or the nearest public health department office for help. The objective is to get an expert radiation technician to the site with an operating survey meter who can determine if the radioactive material is lost or is intact.**
3. **The radiation expert will determine whether the site is safe, will remove the contamination if there is any, and will prepare the gauge for shipment to the Headquarters Lab for repair or disposal.**
4. **In the event of severe damage, it may be necessary to dispose of the source through a local disposal agency licensed for this operation. The radiation technician and Headquarters Materials Lab or local public health department will assist in this action.**

To ease the minds of operators in this regard, gauge manufacturers have never had a damaged gauge requiring extreme security precautions, although they have had a number of gauges thoroughly run over in the years that they have manufactured units.

IMPORTANT PHONE NUMBERS:

RADIATION SAFETY OFFICER:	
XXX REGION MATERIALS LAB:	**(XXX) XXX-XXXXX** **(XXX) XXX-XXXXX**
XXX REGION RADIO:	**(XXX) XXX-XXXX**
Div. of Radiation Protection, DEPT of HEALTH:	**(206) NUCLEAR (206) 682-5327**
HEADQUARTERS MATERIALS LAB:	**(360) 709-5420 (DENNIS DUFFY)**
FIRE: 911 or ____________________	**POLICE: 911** or ____________________
PROJECT ENGINEER:	______________________________

Notify the LAB, Public Health office, police, and Headquarters Materials Lab immediately in the case of a stolen gauge. Refer to the Radiation Emergency Handbook enclosed with the gauge for other procedures.

Required Notices At All Field Storage Areas

"CAUTION — RADIOACTIVE MATERIALS" sign,

"NOTICE TO EMPLOYEES" sign on a nearby bulletin board,

Chapters 246-220, 246-221, and 246-222 of the "Rules and Regulations for Radiation Protection."

DOH Form "Notification of a Radiation Emergency" and a copy of the "Radiation Emergency Handbook."

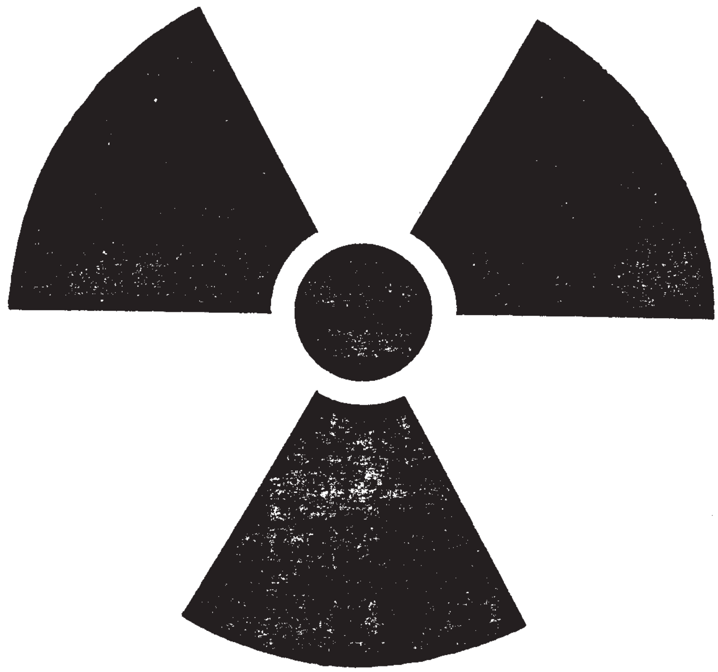
Storage Requirements

Proper storage procedures include:

- That the gauges are kept a minimum of 15 feet away from any place where people may be working on a continuous basis. There should be adequate room for the number of gauges being stored, taking into account the size of the boxes.
- "Permanent and temporary storage areas, must meet the requirements for the 3 levels of security described on page 3-3 of the wook book."

Once storage site has been approved by RSO, the storage site cannot be relocated without prior approval.

CAUTION



RADIOACTIVE MATERIALS

RADIATION EMERGENCY

CALL 206 N-U-C-L-E-A-R
(206) 682-5327

Washington State Department of
Health

DIVISION OF RADIATION PROTECTION

MAIL STOP LE-13, AIRDUSTRIAL PARK-BUILDING 5

P.O. BOX 47827

OLYMPIA, WA. 98504-7827 (206) 586-8942

STATE OF WASHINGTON
NOTICE TO EMPLOYEES

Employer ______________________________

Radioactive Materials
License Number(s) WN- __________________

X-Ray
Registration Number ____________________

In the Radiation Control Regulations, the Department of Health has established Standards for your Protection against Radiation Hazards

YOUR EMPLOYER'S RESPONSIBILITY:
Your employer is required to:

1. Apply these regulations to work involving sources of radiation.
2. Post or otherwise make available to you a copy of the Department of Health regulations, licenses and operating procedures which apply to work you are engaged in, and explain their provisions to you. These documents may be found and examined at: ______________________
______________________________________ .
3. Post each Notice of Noncompliance involving radiological working conditions, proposed imposition of civil penalties and orders. These types of documents may be examined at:
______________________________________ .
4. Provide adequate radiation safety training to you, including training in the use and handling of radiation producing devices, as appropriate.

YOUR RESPONSIBILITY AS A WORKER:
You should familiarize yourself with those provisions of the Department of Health regulations, and the operating procedures which apply to the work you are engaged in. You should observe their provisions for your own protection and protection of your co-workers, patients (if any) and the public.

WHAT IS COVERED BY THESE REGULATIONS?

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports;
6. Options for workers regarding Department inspections;
7. Performance standards for x-ray equipment; and
8. Other related matters.

YOUR RADIATION EXPOSURE HISTORY:

1. Your employer must advise you annually of your exposure to radiation.
2. If you receive an exposure in excess of any applicable limits, your employer must give you a written report within 30 days of learning of the overexposure. The basic limits for exposures to employees are set forth in WAC 246-221-010, 246-221-050, and 246-221-055 of the regulations.
3. Upon termination of your employment, you may ask for a written report of your exposure during the current year up to the date of termination. This may be an estimate as long as it is identified as such.

INSPECTIONS:
All licensed or registered activities are subject to inspection by the Department of Health or its duly authorized representatives. In addition, any worker or representative of workers who believes that there is noncompliance with Chapter 70.98 RCW, the regulations issued thereunder, or the terms of the employer's license or registration with regard to radiological working conditions in which the worker is engaged, may request an inspection by sending a notice of the alleged noncompliance to the Department of Health. The request must set forth the specific grounds for the notice, and must be signed by the worker or the representative of the workers. During inspections, Department inspectors may confer in private with workers, and any worker may bring to the attention of the inspectors any past or present condition which he or she believes contributed to or caused any noncompliance as described above.

INQUIRIES:
Inquiries dealing with radioactive materials may be directed to the Department of Health, Radiation Protection, P.O. Box 47827, Olympia, Washington 98504-7827, Telephone (360) 236-3220. Inquiries dealing with radiation producing machines and facilities may be directed to the Department of Health, Radiation Protection, 1511 3rd Avenue, Melbourne Tower Suite 700, Seattle, WA 98101; Telephone (206) 464-6840.

POSTING REQUIREMENT

Copies of this notice must be conspicuously posted in a sufficient number of places where employees are engaged in activities licensed or registered pursuant to Chapter 246-224 WAC and Chapter 246-235 WAC, by the Department of Health, Radiation Protection, to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from such an area.

DOH321-011 (REV 3/98)

"RHF-3"

NOTIFICATION OF A RADIATION EMERGENCY

In the event of a *Radiation Emergency*, call the following Seattle Number:

(206) N-U-C-L-E-A-R
(682-5327)

Identify the call as a *Radiation Emergency* and give the following information:

1. Your name, organization and call-back phone number.
2. On scene contact person and phone number.

Upon contact with a State Radiation Emergency Response Officer, report the following information:

3. Location and description of incident.
4. Is the event continuing or is it over?
5. Is there an immediate life-threatening situation?
6. Number, condition and location of injured.
7. Describe the radioactive materials, labels, shipping papers, sources, device type, model names, nuclides, and curie content (if known).

POST

Washington State Department of Health
Division of Radiation Protection

DOH Pub 320-002 (Rev. 11/91)

Procedures in Case of Accident (WSDOT Nuclear Moisture/Density Gauge Emergency)

General

The operator must protect human life first, then property, from damage due to a radiation incident.

We must prevent the raw radioactive material from escaping to the atmosphere or environment.

The source material is encapsulated in two stainless steel, welded containers, which are further securely mounted into the gauge enclosure. It is highly unlikely that the material could escape in the event of a severe accident or fire; however, our protective program must ensure that we plan for this eventuality.

The first action to be taken in the event of an accident with the Nuclear Moisture/Density Gauge is to **keep other people away from the site**.

Then take the following actions according to the extent of the accident as described in Condition A or B:

A. The gauge is **superficially damaged**, dented, flooded, or otherwise injured from a drop, minor runover, etc. The enclosure is in one piece with a minor break or two in the sheet metal or casting and the source is obviously in place — at least the source location is not torn apart.

   1. Turn the gauge over to view the source area, if necessary. Do not walk through the site material where the gauge was pushed or pulled. Inspect the source area visually to ensure no damage to shutter or source mounting.

   2. If source area is intact, pick up gauge, and place it in the storage container. Call the Radiation Safety Officer and your Project Engineer before returning the gauge to the permanent storage area.

      Do not ship the gauge without Headquarters' Materials Lab approval or knowledge.

B. The gauge is **broken apart, severely burned, severely crushed** with parts strewn around, or the source area is visually damaged.

   1. **Freeze the site.** (Contain the damage site for 15 feet (5 meters) in any direction.) Do not walk through the damage site. If radioactive material is loose, it can be picked up and tracked elsewhere.

   2. **Call the Radiation Safety Officer**, Project Engineer, and/or the nearest public health department office for help. The objective is to get an expert radiation technician to the site with an operating survey meter who can determine if the radioactive material is lost or is intact.

   3. The radiation expert will determine whether the site is safe, will remove the contamination if there is any, and will prepare the gauge for shipment to the Headquarters' Materials Lab for repair or disposal.

4. In the event of severe damage, it may be necessary to dispose of the source through a local disposal agency licensed for this operation. The radiation technician and Headquarters' Materials Lab or local public health department will assist in this action.

To ease the minds of operators in this regard, gauge manufacturers have never had a damaged gauge requiring extreme security precautions, although they have had a number of gauges thoroughly run over in the years that they have manufactured units.

Important Phone Numbers:

See your Transportation Information Sheet for phone numbers.

Notification of a Radiation Emergency (Contact to be by the Radiation Safety Officer)

In the event of a Radiation Emergency, call the following Seattle Number:

(206) N-U-C-L-E-A-R (682-5327)

Identify the call as a Radiation Emergency and give the following information:

1. Your name, organization, and call-back phone number.
2. On scene contact person and phone number.

Upon contact with a State Radiation Emergency Response Officer, report the following information:

3. Location and description of incident.
4. Is the event continuing or is it over?
5. Is there an immediate life-threatening situation?
6. Number, condition, and location of injured.
7. Describe the radioactive materials, labels, shipping papers, sources, device type, model names, nuclides, and curie content (if known).

Stolen Gauge

Notify Radiation Safety Officer immediately in the case of a stolen gauge. Refer to the *Radiation Emergency Handbook* enclosed with gauge for other procedures.

Tracking

Tracking the location of our gauges is an important function within the law. The regional materials lab has control of the gauges and assigns them to the project offices. This form is used for all transfers.

Washington State Department of Transportation

Statement of Receipt of Radioactive Material

1. I accept responsibility for the physical security, safe handling, and transportation of the radioactive material listed below.
2. I have read, familiarized myself with, and understand the Washington Radiation Control regulations of the Department of Health, Title 246, WAC, Radiation Emergency Handbook, and the Washington State Department of Transportation Administrative Instructions for use of Nuclear Gauges, Section 9-06 of the Construction Manual.
3. I will comply with and ensure that all persons, including observers, comply with the listed safety rules and regulations.
4. I will not delegate custody of any state-supplied radioactive material to any unauthorized individual.
5. I received Nuclear Gauge - Model Number ____________ Serial Number ____________
6. Gauge Destination ____________
7. Problems / Comments ____________

☐ Repair ☐ Transfer
☐ Calibrate ☐ Retire

____________ Signature of Person Receiving Sources ____________ Date

____________ Signature of Person Issuing Sources ____________ Date

Return to Region By ____________ Date

DOT Form 351-021
Revised 4/98

Distribution: Original: Issuer's Permanent Copy
Copy 1: Receiver's Permanent Copy
Copy 2: Issuer's Temporary Copy

Daily Use Log Book

There will be a log book that shows where the gauge will be that day and who took it out. The person checking out the gauge shall legibly sign the logbook or provide a signature and print their name, if their signature is not legible. This book should stay in your storage area.

When a gauge is brought in for repair and exchanged for another, just record the new gauge number and continue the record.

6:P65:DP/NGOQC

Part 5

Definitions

General Definitions

Absorption

The process by which radiation imparts some or all of its energy to any material through which it passes.

Alpha Particle

A charged particle that is emitted from the nucleus of an atom and that has a mass and charge equal in magnitude to those of a helium nucleus, i.e., two protons and two neutrons.

Atom

Smallest particle of an element which is capable of entering into a chemical reaction.

Atomic Number

The number of protons in the nucleus of a neutral atom of a nuclide.

Atomic Weight

The average relative weight of an element referred to some element taken as a standard.

Attenuation

The process by which a beam of radiation is reduced in intensity or energy when passing through some material.

Beta Particle

Charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to those of the electron.

Calibration

The determination of a measuring instrument's variation from a standard, to ascertain necessary correction factors.

Curie

That quantity of a radioactive nuclide disintegrating at the rate of 3.7×10^{10} atoms per second. (Abbreviated: c.)

Millicurie

One thousandth of a curie (3.7×10^{7} disintegrations per second.). Abbreviated mc.

Decay, Radioactive

Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

Electron

Negatively charged particle which is a constituent of every neutral atom. Unit of negative electricity equal to 4.8 ∞ 10^{-10} electrostatic units of 1.6 ∞ 10^{-19} coulombs. Its mass is 0.000549 atomic mass units.

Gamma Ray

Short wavelength electromagnetic radiation of nuclear origin.

Half-Life, Radioactive

Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

Intensity

Amount of energy per unit time passing through a unit area perpendicular to the line of propagation at the point in question.

Ion

Atomic particle, atom, or chemical radical bearing and electrical charge, either negative or positive.

Ionization

Process or the result of any process by which a neutral atom or molecule acquires either a positive or a negative electric charge.

Isotope

Isotope are atoms that have the same number of protons in their nuclei, hence the same atomicnumber, but a different number of neutrons, therefore, a different atomic mass. Isotopes of a particular element have almost identical chemical properties.

Neutron

One of three elementary particles of an atom, which is part of all nuclei heavier than hydrogen.

Nucleus

The center of an atom, it is composed of one or more protons and usually some neutrons as well.

Radiation

Energy traveling through space in the form of waves, particles, or bundles called photons.

Radiation Background

Radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present.

Radioactivity

Process whereby certain nuclides undergo spontaneous disintegration in which energy is liberated, generally resulting in the formation of new nuclides. The process is accompanied by the emission of one or more types of radiation, such as alpha particles and gamma photons.

Definitions for Health Safety

Contamination, Radioactive

Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. The harm may be in vitiating the validity of an experiment or a procedure, or in actually being a source of danger to personnel.

Dose (Dosage)

According to current usage, the radiation delivered to a specific area or volume or to the whole body. Units for dose specifications are roentgens for X- or gamma rays, reps, or equivalent roentgens for beta rays. In radiology the dose may be specified in air, on the skin, or at some depth beneath the surface; no statement of dose is complete without specification of location. In recent years there has been an increasing tendency to regard a dose of radiation as the amount of energy absorbed by tissue at the site of interest per unit mass.

Dose Rate (Dosage Rate)

Radiation dose delivered per unit time.

Dosimeter, Thermoluminescence

An integrating detector that utilizes a phosphor sensitive to ionizing radiation. The phosphor stores the energy of the ionization within itself and releases it as low-energy photons (light) when heated. The total amount of light released is proportional to the total absorbed dose.

Exposure

The incidence of radiation upon inanimate or living matter by intent or accident.

Monitoring

Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

Radiation, External

Exposure to ionizing radiation when the radiation source is located outside the body and the radiation must then penetrate into the deeper tissue.

Radiation, Internal

Exposure to ionizing radiation when the radiation source is within the body as a result of deposition of radioelements in body tissues.

Radiation, Ionizing

Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

RAD

A measure of the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest.

Quality Factor (Q)

The factor dependent on linear energy transfer by which absorbed doses are multiplied to obtain a quantity that expresses the effect of the absorbed dose on a common scale for all ionizing radiations.

Roentgen

An exposure dose of X- or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

Roentgen Equivalent Man (rem)

The unit used to express human biological doses as a result of exposure to one or many types of ionizing radiation. The dose in rems is equal to the absorbed dose in rads times the *quality factor* of the type of radiation being absorbed.

Shield

A body of material used to prevent or reduce the passage of particles of radiation. A shield may be designated according to what is intended to absorb, as a gamma-ray shield or neutron shield or according to the kind or protection it is intended to give, as a background, biological, or thermal shield.

Survey, Radiological

Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements, or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

Acknowledgment of the Hazards of Working With Radiation Sources

I have been instructed to read the applicable sections of Chapters 246-220 Radiation General Provisions; 246-221 Radiation Protection Standards; and 246-222 Radiation Protection - Worker Rights of the Department of Health's latest manual on "Sealed Sources Edition Rules & Regulations for Radiation Protection" and understand the hazards, and my rights in working with or around radiation sources.

Name (print): ____ Date: __________

Signature ____